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Green buildings: issues for New Zealand

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Abstract

If the mission of ‘green’ rating tools is to accelerate the transformation of the global built environment towards sustainability then a high priority must be placed on the energy consumed by buildings since energy supplies from various sources are depleting. This paper examines the apparent anomaly that almost all designs of ‘green’ office developments in New Zealand have high proportions of unshaded glazing. They are sealed, lightweight, air-conditioned buildings that are dependent on an uninterrupted supply of electricity in order to remain habitable. From an architectural science point of view, these characteristics are not normally associated with sustainability. The paper will investigate the drivers behind the highly glazed buildings recently realized in New Zealand, including those components of ‘green’ rating tools that favour this building type.

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1. Introduction

As the number of ‘green’ rated office buildings in New Zealand increases there is a distinct pattern in their appearance and method of environmental control. Of those featured on the web site of the New Zealand Green Building Council (NZGBC) [1] the majority are highly glazed, thermally lightweight, sealed and air-conditioned buildings. These are characteristics that are not normally associated with ‘low-energy’ or ‘sustainable’ design. There appears to be a difference between a ‘green’ building and one that adheres to good architectural science principles.

Although ‘green’ accreditation considers many issues that are beyond the scope of architectural science, such as management, land use and transport, it would appear that energy, one of the central issues of both architectural science and sustainability, is inadequately addressed.

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This paper will put forward the case for reviewing the weighting that energy should have within the New Zealand accreditation process and for altering those key aspects of the rating criteria where there is an apparent conflict between 'green' accreditation and architectural science.

The paper will first review the issue of future energy supplies in New Zealand and will conclude that there is likely to be a seasonally inadequate supply of electricity that may result in energy rationing. Under these circumstances it will be argued that sealed, air-conditioned buildings become a high risk as an inadequate or interrupted supply of electricity will result in overheating and render them uninhabitable, unproductive and unsustainable.

The paper will then address some of the key criteria of rating tools involving architectural science including daylighting, views, internal noise levels, thermal comfort and energy. It will be argued that aspects of these 'green' criteria distort fundamental principles of architectural science and are incongruous with current research and trends in environmental control systems for sustainable buildings.

Lastly, there is a brief discussion concerning the motivation for 'green' accreditation and the conflict in architectural design between, on the one hand, the brand image of a building and, on the other, characteristics of the building envelope that are associated with good environmentally sustainable design.

1.1. The relationship of energy and sustainability in New Zealand buildings

To be sustainable, buildings should usefully last for many generations. This requires building designers to have some knowledge of the future climate and the resources available to maintain the operations, in particular the energy consumption, of buildings. The New Zealand climate is predicted to get hotter and an energy gap to emerge as fossil fuels deplete and seasonal hydroelectricity production declines due to the retreat of glaciers. The historical peak demand of electricity for buildings has been for winter heating. This is now shifting to a summer cooling demand which does not favour highly glazed buildings. Indeed, despite the complex New Zealand climate, varying from warm subtropical in the far north to cool temperate in the far south, due to its extent in latitude (between 34 and 48 degrees south), the majority of the population is concentrated in the northern island, where the climate is milder and the construction industry more active.

In a changing climate with predicted increases in average temperatures [2], 'green' buildings in New Zealand are still being designed with a dependence on air-conditioning. There appears to be an assumption that there will be an adequate supply of energy for the whole lifetime of the building that can maintain current comfort standards. This may be the case for buildings that can be certain of a secure and enduring supply of renewable energy. However, for the overwhelming majority of buildings, there is no unconditional security of an uninterrupted energy supply in the future and increasing evidence of the need for energy rationing.

1.2. Climate change, peak hydro and the availability of electricity in New Zealand

Apart from 'peak oil' and 'peak gas', New Zealand also faces 'peak hydro'. The hydro industry has long formed the backbone of New Zealand's successful power sector. It has provided a relatively constant 60% of total electricity production since the 1930s and enabled the country to enjoy some of the lowest power tariffs in the world.

The fear remains that a severe drought will trigger power rationing and the vulnerability of the power sector to dry years is becoming increasingly apparent with the decline of the Maui gas reserves, the New Zealand's largest gas and oil field, which has provided the majority of the country's hydrocarbons since its discovery in 1969.

One of the biggest problems with New Zealand's existing hydro schemes is the lack of water storage

capacity. New Zealand's hydro schemes do not benefit from large reservoir capacity and most have just several months' worth of storage [3]. They are therefore more vulnerable to annual or even seasonal fluctuations in precipitation and snow melt. For example, the variation in electricity production during the course of a year in the 1990s was around 20%.

In January 2010 the World Glacier Monitoring Service (WGMS) stated [4]: "Glaciers across the globe are continuing to melt so fast that they may well disappear by the middle of this century." The WGMS records data for nearly 100 of the world's approximately 160,000 glaciers, including 30 'reference' glaciers, with data going back to at least 1980. New Zealand's glaciers have an estimated volume of about 53 Km³ and have been gradually decreasing in volume over the last century by about one quarter to one third [5]. As more than half the water entering hydroelectric lakes in New Zealand comes from glacial water [6], global warming will have an impact on energy production. Predictions of a 3°C [2] average temperature rise and 15% increase in precipitation indicate a significant decrease in snow accumulation resulting in increased flows of 40% in the winter and a 13% decrease in the summer.

With increased temperatures, the peak demand for electricity will shift towards summer rather than winter. There will also be an increased demand for water for irrigation during the summer – which could be significant considering that agriculture still remains hugely important to New Zealand, especially in terms of export trade. This will reduce the ability of the hydroelectric power sector to provide an unfluctuating supply of electricity and could result in significant reduction in future supplies.

The predicted increase in electricity production from wind power will play an important role in replacing the decreased production due to fossil fuels and hydro in the future. However, wind power is intermittent, cannot be relied upon to match with peak demands and is expensive to store. This has recently been illustrated in the UK [7] where a fall of 7.5% in power obtained from wind, hydro and other renewable sources in the first 3 month of 2010 was blamed on a dry winter with low wind speeds.

There will also be competition by other users for the electricity produced by wind power. The electric vehicle industry [8] views the night-time production of electricity from wind power as an obvious alternative energy source to oil-derived fuels and, since transport currently consumes almost half the total energy supply in New Zealand, electric vehicles will have the potential to consume nearly all electricity produced by wind power. If this were the case, it would leave little residual energy for buildings.

There is also likely to be a significant increase in demand of electricity in both winter and summer due to the increased use of heat pumps in residential buildings. Government subsidies for heat pump installations have led to a significant growth in the heat pump market. Research by the Building Research Association of New Zealand (BRANZ) has indicated [9] that these devices are displacing non-electric heating, thereby increasing the demand for electricity in the winter. Furthermore many households, almost two thirds of the sample surveyed, are using their heat pumps for cooling as well as heating thereby introducing a new demand for electricity in the summer that did not previously exist.

Higher average temperatures in New Zealand will have the combined effect of increasing demand on electricity for summer cooling while decreasing the output of hydro power throughout the summer months. 'Peak oil' and its consequences are likely to increase the demand on electricity throughout the year if there is to be a shift towards the use of electric vehicles. While wind power will help offset the loss in energy supply, there remains a potential gap between supply and demand in the near future.

2. The weighting of 'energy' in 'green' rated buildings

With a potential energy gap, new buildings play an important role in reducing electricity demand and there is a clear priority for 'green' buildings to address this issue.

While all building designs must achieve the minimum Building Code standards in New Zealand (NZS 4243:2007), 'green' building rating systems offer a means of improving on these minimum standards by

increasing the environmental performance of the building envelope.

The first Green Star NZ rating tool was launched in New Zealand in 2007. It was implemented by the New Zealand Green Building Council (NZGBC) in partnership with the building industry, based on the Australian Green Star tool. Like other rating tools, the Green Star rating tool measures ‘energy’ as one of the criteria for achieving accreditation – together with management, Indoor Environmental Quality (IEQ), transport, water, materials, land use and ecology, emission and innovation.

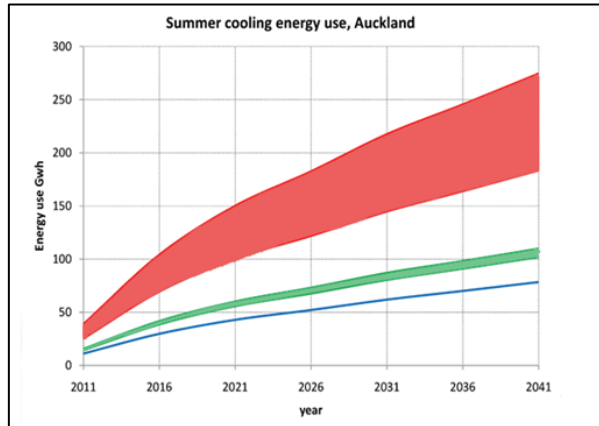


Fig. 1. Predicted increase in energy consumption for cooling houses in Auckland, New Zealand due to: a) growth (blue line); b) climate change (green line); c) heat pumps per household (red). Derived from: Page I. *Regional Heat Pump Energy Loads. Report E528*. Wellington: BRANZ Ltd; 2009

Green Star New Zealand has given ‘energy’ for office design a weighting of 25% of the total score, although less than 2/3rds of this score relates to the performance of the building envelope. From data available on the NZGBC web site [1] many high profile ‘green’ buildings do not even achieve half of this score. For example, for those case studies of air conditioned office buildings illustrated on the web site, the average score for ‘energy’ is approximately 50% of that available. This means that the ‘rating tool’ allows building designs to be accredited when ‘energy’ is valued at approximately 12.5% (50% of 25%) of the potential total rating tool value. Furthermore, a new building can potentially achieve a 4 or 5 star rating (out of 6 stars achievable, signifying ‘World leadership’) while only just achieving the minimum required code standards for the thermal performance of the building envelope. This means it is possible to achieve ‘Best practice’ or ‘New Zealand Excellence’ rating while the building envelope is almost breaking the law (New Zealand Building Act).

2.1. The environmental performance of highly glazed buildings

One of the most important rules-of-thumb for the environmental design of a building is the proportion of glass on a building facade (% glazing). Glass is the ‘weak-link’ in the environmental performance of a building as it is the most significant route by which energy enters or leaves the building envelope. All visible energy (daylight) comes through windows, almost all solar heat gains come through windows and a given area of window loses almost 10 times more energy through it than a similar area of insulated wall.

Balancing the energy demand of heating, cooling and lighting is usefully illustrated by the ‘LT Method’ of predicting environmental performance, developed at Cambridge University [10]. The results of this study showed that for well insulated buildings in temperate climates it is difficult to justify a proportion of glazing of more than 50%, irrespective of orientation, internal lighting level or internal heat

gains.

However, it could be argued that in New Zealand a ‘temperate climatic model’ is inappropriate, in particular for the Climate Zone 1 - as defined by the New Zealand standards (NZS 4218:2004) – including the north of the northern island. To overcome this, it would be better refer to the adaptation of the LT Method developed by the University of Queensland [11] for a sub-tropical climate (LTV Method). This model indicated that an even lower proportion of glazing was optimal. As the climate warms there is an even greater requirement to reduce the proportion of glazing in a building’s envelope. This also echoes the advice of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) who have recognised the problems associated with glazing ratios over 50% [12].

Apart from the trend of ‘green’ rated buildings to be highly glazed there has also been the trend to introduce double-skin facades as part of the environmental control system of the building envelope. Double skin facades originated in Europe as a means of reducing noise in naturally ventilated buildings with all-glass facades. They evolved and were subsequently claimed by the architectural press to be energy efficient. While there are many different types of double-skin facade, when applied as an additional skin on a sealed, air-conditioned building their measured performance has been questionable [13] [14].

Although double-skin facades are frequently installed and claimed to be a method of improved cooling, there is little evidence to illustrate their effectiveness. The Lawrence Berkeley National Laboratory [15] reporting on high performance building facades stated that: “It has been extremely difficult to find any objective data on the performance of actual buildings implementing some of these solutions, particularly double-skin façades [...]. Subjective claims abound in the architectural literature.” The authors also refer to other findings: “Energy-efficiency is not the foremost benefit of double-skin façades and that such benefit derived may well be small, depending upon circumstances.”

Even if double-skin facades were shown to be energy efficient, the installation of them may not have been necessary in the first place, had a reduced proportion of fenestration been designed. They are potentially cooling the problem they have created.

2.2. Criteria in rating tools that conflict with sustainability

Historical comfort standards are emerging as a significant impediment to reducing energy demand in buildings [16]. With the likelihood of both increasing average temperatures due to climate change and also reduced energy supply, human adaptation to a changing climate in the longer term is more appropriate than expending more energy on cooling. New Zealand has a climate that, assuming a building can be appropriately designed, does not require air-conditioning for buildings to remain within adaptive comfort tolerances. However, while natural ventilation is encouraged in rating tools, there is no active discouragement of air-conditioning.

Apart from thermal comfort conditions, air quality is also an issue that has not deterred air-conditioning. The points available for mechanical ventilation and 100% fresh air intake can still be exploited by the design of a full air conditioning system.

Standards for noise levels within both general and private offices, incorporated in IEQ for rating tools, also promote sealed buildings that negate natural ventilation. The internal noise standards can only be achieved in an urban area by ensuring that windows are not opened [17].

Points are also given for increased floor area with daylight factor bigger than 2.5% (30, 60, 90% of net lettable area, NLA). However, while maximising the use of natural light is beneficial, the depth of the room should also be a limiting factor in order to avoid over-glazing. The linear increase in the illumination of the floor area requires an exponential increase in glazing proportion to achieve this. This can be compared with BREEAM’s (Building Research Establishment Environmental Assessment Method)

daylight assessment procedure which limits natural light to a 7 m depth and requires a calculation for daylight uniformity as a more reliable indicator of the perception of daylight [18].

The criteria for external views could also encourage over-glazing. The basis of these criteria should be balanced with other research on user satisfaction and views. For example, the UK Building Research Establishment [19] indicated that there was no perceived increase in satisfaction with glazing over 30% of the internal elevation.

2.3. Highly glazed façade: environmental performance or architectural style and brand image?

A review of a prominent ‘green’ rated building in New Zealand [20] stated that “Extensive and detailed modelling of the building facade was undertaken to determine a system that would provide the best balance of light transmission versus heat gain.” This particular building is almost 90% glazed with little solar protection and is fully air conditioned, thermally lightweight and is conspicuous by its artificial lighting that remains on for much of the day. According to the architectural science modelling methods described above (2.1) as well as the Lawrence Berkeley Laboratory report [12] and ASHRAE standards referred to [15], such a building envelope is inherently energy inefficient.



Fig. 2. Examples of recent ‘green’ rated buildings in Auckland, New Zealand

This brings into question whether rating tools are being used for improved environmental design or whether they are being used for brand image. This issue was addressed in research carried out a Land Care Research in New Zealand [21] on the first 450 LEED (Leadership in Energy and Environmental Design) accredited buildings in the US. There is growing evidence from the body of research into both the design and actual performance of LEED certified buildings that the prime motivation behind the use of rating tools is for commercial marketing and promotion rather than for significant environmental concerns.

In architecture, this is where there is a significant conflict between style and performance. Low standards for energy efficiency of the building envelope and a low value given to ‘energy’ in rating tools allow the opportunity to use large areas of glazing. Many high profile ‘green’ buildings in NZ have taken this opportunity and have been designed with a large proportion of glazing for purposes of image. For example, the Green Star NZ Case Studies [1] of new office developments average in excess of 80% of glass on those facades that directly serve office spaces and, in some cases, approach 100%.

The drive for air-conditioning is largely motivated by the corporate clients whose key drivers are

dictated by brand image and ‘real estate strategy’ of achieving Grade A or B rated space [22]. This is another area where rating tools are also fostering the use of air-conditioning and could provide improved guidance by balancing some of the conflicting requirements and standards of ‘IEQ’ with ‘energy’.

3. Conclusions

Many of the office designs that have ‘green’ accreditation in New Zealand were substantially designed before the rating system was introduced. The fundamental characteristics of the building envelope are likely to have been decided before any ‘green’ analysis could be applied. Many of these designs have subsequently been able to achieve a ‘green’ rating with little compromise to their appearance. Having said that, they have worked within the constraints of the rating system and adhered to its requirements. However, while the total energy consumption of these buildings is small compared with the whole building stock, their impact has been disproportionately large due to media coverage.

If the combined effects of climate change and fuel depletion result in reduced and insecure electricity supplies, then highly glazed, sealed and air-conditioned buildings could frequently become uninhabitable and unproductive. Real estate’s Grade A office space will become undesirable and the naturally ventilated and daylit buildings with appropriate shading will be shown to be sustainable. It is the characteristics of these building types that should be promoted further in ‘green’ rating systems.

Changing a few of the criteria for ‘green’ rating could marginally shift the rating tool towards encouraging an improved performance of the building envelope. Ultimately an insecure supply of electricity will fundamentally alter the weighting for ‘energy’ within a rating tool and the idea that a building, which is completely dependent on electricity in order to remain habitable, could be considered sustainable is in need of review.

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